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Exam #1
Biophysical Chemistry
Chemistry 130A
Fall 2001

Justify all your assumptions!

Show all your calculations!

Make sure all your conclusions are physically reasonable.

Keep track of units and significant digits!

Underline or Box all your final answers!

Keep you answers brief!

Exams in pencil won't be regraded.

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Bondlength (pm) and bond energy (kJ/mol)

Bond	Length	Energy	Bond	Length	Energy
H--H	74	436	H--C	109	413
C--C	154	348	H--N	101	391
N--N	145	170	H--O	96	366
O--O	148	145	H--F	92	568
F--F	142	158	H--Cl	127	432
Cl-Cl	199	243	H--Br	141	366
Br-Br	228	193	H--I	161	298
I--I	267	151			
			C--C	154	348
C--C	154	348	C=C	134	614
C--N	147	308	C≡C	120	839
C--O	143	360	C=O		725
C--S	182	272	O--O	148	145
C--F	135	488	O=O	121	498
C--Cl	177	330			
C--Br	194	288	N--N	145	170
C--I	214	216	N≡N	110	945

Temperature
(SI unit: kelvin)

Kelvin	= $^oC + 273.15$
Celsius	= $(5/9)(^oF-32)$
Fahrenheit	= $(9/5)(^oC) + 32$

Energy
(SI unit: joule)

Joules	= 1 kg * m^2/s^2
	= 0.23901 calorie
	= 9.478×10^{-4} btu
Calories	= 4.184 joules
	= 3.965×10^{-3} btu
BTU	= 1055 joules
	= 252.2 calories

Pressure
(SI unit: pascal)

1 pascal	= N/m^2
	= 1 kg/m * s^2
1 atm	= 760 mmHg (torr)
	= 101.325 kPa
1 bar	= 10^5 pascals

Standard Enthalpies of Formation, ΔH_f°, at 298 K

Substance	Formula	ΔH_f° (kJ/mol)	Substance	Formula	ΔH_f° (kJ/mol)
Acetylene	$C_2H_2(g)$	–26.7	Hydrogen chloride	$HCl(g)$	–92.30
Ammonia	$NH_3(g)$	–46.19	Hydrogen fluoride	$HF(g)$	–268.6
Benzene	$C_6H_6(l)$	49.04	Hydrogen iodide	$HI(g)$	25.9
Calcium carbonate	$CaCO_3(s)$	–1207.1	Methane	$CH_4(g)$	–74.85
Calcium oxide	$CaO(s)$	–635.5	Methanol	$CH_3OH(l)$	–238.6
Carbon dioxide	$CO_2(g)$	–393.5	Propane	$C_3H_8(g)$	–103.85
Carbon monoxide	$CO(g)$	–110.5	Silver chloride	$AgCl(s)$	–127.0
Diamond	$C(s)$	1.88	Sodium bicarbonate	$NaHCO_3(s)$	–947.7
Ethane	$C_2H_6(g)$	–84.68	Sodium carbonate	$Na_2CO_3(s)$	–1130.9
Ethanol	$C_2H_5OH(l)$	–277.7	Sodium chloride	$NaCl(s)$	–411.0
Ethylene	$C_2H_4(g)$	52.30	Sucrose	$C_{12}H_{22}O_{11}(s)$	–2221
Glucose	$C_6H_{12}O_6(s)$	–1260	Water	$H_2O(l)$	–285.8
Hydrogen bromide	$HBr(g)$	236.23	Water vapor	$H_2O(g)$	–241.8

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1. (8 pts) True or False

(a) If a Carnot engine has T_{hot}= 60 °C and T_{cold}= 30 °C is efficiency is ½.

TRUE **FALSE**

(b) If, for some process we find ΔE= -328.4 J and ΔH= 218.3 J then our system cannot be an ideal gas.

TRUE **FALSE**

(c) $\oint dq$ is always non-zero, for any possible cycle.

TRUE **FALSE**

(d) q=0 for any adiabatic process, even if it is reversible.

TRUE **FALSE**

(e) The heat capacity of water depends upon whether or it is a gas or a liquid.

TRUE **FALSE**

(f) All gases are ideal gases

TRUE **FALSE**

(g) pV is a state function.

TRUE **FALSE**

(h) $\frac{dq}{T}$ is always a state function.

TRUE **FALSE**

(i) Work is always calculated as F*ΔX

TRUE **FALSE**

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2. (12 pts) Bob the Bass

Bob the Bass has a swim bladder containing 0.5 moles of an ideal gas ($C_v = \frac{3}{2}nR$). Assume that the swim bladder is a closed system.

(a) Bob the Bass swims from the surface of a lake, where the pressure is 1 atm, to a depth of 30 meters below the surface (where pressure is 2 atm). Suppose that during Bob's descent, he swim bladder contracts *isothermally* and *reversibly*. If his swim bladder is at a temperature of 25 °C, find ΔE, ΔH, q, and w (always in Joules) for the swim bladder.

(b) At the depth of 30 feet (2 atm pressure), Bob is hooked by an angler. After a furious struggle, he is hauled to the surface (1 atm pressure). During this time period, Bob uses internal muscles so that the swim bladder is held at a constant volume (hint: the temperature must change). Find ΔE, ΔH, q, and w (in Joules) for the swim bladder.

(c) Once on the surface, Bob's swim bladder expands until the volume and the temperature are the same as in part 1a. Find ΔE, ΔH, q, and w (in Joules) for the swim bladder.

(d) Determine the total change in internal energy and enthalpy for the entire process starting from 1a and ending at 1c. Explain why you could have arrived at this answer without doing any calculation.

(e) Determine the total work done and heat generated by parts 1a-c.

(f) How many times must be Bob be caught from a depth of 30 m, released, and allowed to swim down again to 30m before he passes away?

Assume the following:

- Bob weighs 5 kg, and has the heat capacity of water (4.18 J/g K).
- All the heat from parts 1a-c are transferred directly to his body, and are not passed on to his environment.
- Bob dies at 40 °C.

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(g) Bob the bass is served for breakfast. In the process of preparing Bob for consumption, the following occurs:

Bob is heated from room temperature (30 °C) to 200 °C, where he undergoes a phase transition from raw fish to cooked fish. He is then allowed to cool down to room temperature.

Given that Bob weighs 5 kg and

$C_{p,raw}$ = 4.18 J/g K $\quad$ $C_{p,cooked}$ = 1.32 J/g K $\quad$ $\Delta H(200\ °C)_{raw \rightarrow cooked}$ = 213.3 kJ/kg

Find $\Delta H(30\ °C)_{raw \rightarrow cooked}$ in kJ/kg.

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3. (12 pts) One Shots

These questions require only ***very*** short answers. Keep your answers as short as possible; no more than 2-3 sentences. Anything after the third sentence will not be graded.

(a) In general, C_v differs from C_p. Explain, physically, why this is true.

(b) Computational biologists utilize algorithms to predict what tertiary structures peptides will assume. Often these scientists use different thermodynamic quantities to judge whether a certain protein configuration is stable.

In one computer experiment, a scientist estimated from her calculations the entropy of a protein at 0 K and found that it did not equal zero. Is there something wrong with her algorithm? Explain.

(d) A Protein crystallographer's biggest challenge is to obtain high quality crystals of protein. The proteins in a solution, under proper conditions, will come together in an ordered, regular arrangement. Using what you know about thermodynamics explain how it is possible to form this highly-ordered, crystalline structure from a disordered solution.

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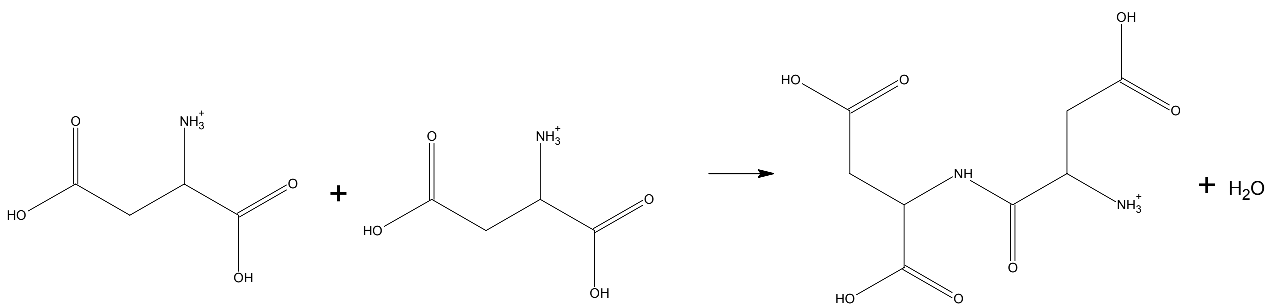
4. (10 pts) Bond Energies

Consider the following reaction in which two aspartic acid molecules join to form a dipeptide.



(a) What is ΔH_r, based on the bond dissociation energies from the information page?

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5. (17 pts) Chemical Reactions

0.727 grams of D-ribose ($C_5H_{10}O_5$) is placed in a calorimeter and ignited in the presence of excess oxygen, causing the temperature to rise by 0.910 K.

(a) What is the balanced reaction of the combustion (assuming complete conversion into CO_2 and H_2O)?

(b) To calibrate your calorimeter you combust $6.76*10^{-3}$ moles of benzoic acid, which has a heat of combustion of -3251 kJ/mol; this causes the temperature to rise by 1.940 K. What is the heat capacity if the calorimeter?

(c) Using your result from part b (if you didn't answer part b assume the heat capacity was 10 kJ/K), calculate ΔH of combustion for D-ribose (i.e. ΔH_r for the reaction you wrote in part a)

(d) Using your result from part c (if you didn't get answer use ΔH_r= -1000 kJ/mol), and the values from the tables on the information page, calculate ΔH_f for D-ribose.